A New Paradigm for Post-Cardiac Event Resistance Exercise Guidelines

Jenny Adams, PhD[a,*], Matthew J. Cline, MS[b], Matt Hubbard, MS[a], Tiffany McCullough, BS[a], and Julie Hartman, MS[a]

Existing guidelines for resistance exercise in cardiac rehabilitation are vague and/or overly restrictive, limiting the ability of cardiac rehabilitation programs to help patients achieve their desired levels of daily activity in a timely manner after cardiac events. This study examines the illogical nature of the existing guidelines in relation to the activities of daily living patients are expected or required to carry out during the period of cardiac rehabilitation and the existing recommendations for dynamic exercise in cardiac rehabilitation. An improved method is proposed for prescribing resistance exercise in cardiac rehabilitation. A tool is presented that stratifies the risk associated with each of 13 common resistance exercises for 3 cardiac rehabilitation diagnosis groups (myocardial infarction [MI], pacemaker or implantable cardioverter defibrillator implantation, and coronary artery bypass graft surgery) that, if used in conjunction with blood pressure and heart rate measurements, will safely facilitate more efficacious resistance training in cardiac rehabilitation patients. In conclusion, changing the approach to resistance exercise in cardiac rehabilitation will accelerate patients' return to their desired levels of daily activity, improving patient satisfaction and decreasing cardiac rehabilitation program attrition. **(Am J Cardiol 2006;97:281–286)**

Current guidelines for resistance exercise after cardiac events, including myocardial infarction (MI), pacemaker or implantable cardioverter-defibrillator (ICD) implantation, and coronary artery bypass graft (CABG) surgery, are overly restrictive, leading to unnecessary long-term disability, and fail to take into account the variation in rehabilitation needs or capabilities of patients after different cardiac events. We examine some of the problems with current recommendations given to patients after MI, pacemaker or ICD implantation, and CABG surgery, as well as the consequences of following these recommendations, and propose new standards on which guidelines should be based.

Methods

Current resistance training recommendations from the American Association of Cardiovascular and Pulmonary Rehabilitation (AACVPR) and the American College of Sports Medicine (ACSM) for patients who have undergone each of these cardiac events are listed in Table 1. As can be seen, these recommendations address only the weights of dumbbells to be used and the timing of resistance exercise, without considering which exercises might be safe on the basis of surgical site or clinical condition or patient capability on the basis of factors such as age, weight, and previous fitness level.

To assess the limitations imposed by the very restrictive weight limits (1 to 5 pounds) recommended for the first 3 to 12 weeks after a cardiac event on patients' daily activities, we used a Chatillon medical dynamometer (model CSD200C, Largo, Florida) to measure the push and pull forces of 32 commonly performed activities. Dynamometer measurements were obtained at the slowest possible rates because forces are greater when activities are performed explosively.[1] The pull forces of 1-, 3-, 5-, and 10-pound hand weights were obtained for use as reference values with which other activity force measurements could be compared.

To investigate the instructions given to patients by physicians or surgeons after cardiac events, we surveyed 78 patients (52 men, 26 women; age range 39 to 84 years) in the cardiac rehabilitation program at Baylor Medical Center, Garland, Texas, who had undergone surgery involving sternotomy from 1995 to 1997. In 2005, we repeated the survey with 20 patients in the cardiovascular rehabilitation program at the Baylor Jack and Jane Hamilton Heart and Vascular Hospital, Dallas, Texas.

To assess the potential of resistance exercises to cause mechanical damage to surgical sites in developing new cardiac rehabilitation resistance training recommendations, we used kinesiologic analysis (analysis of the anatomy, physiology, and movement patterns of the exercise) of 13 resistance activities in the *Exercise and Muscle Directory*[2]

[a]Baylor Jack and Jane Hamilton Heart and Vascular Hospital, Dallas, Texas; and [b]Grady Memorial Hospital-Ohio Health, Delaware, Ohio.
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* Corresponding author: Tel: 214-820-1395; fax: 214-820-1412.
E-mail address: jennya@baylorhealth.edu (J. Adams).

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Table 1
Current cardiac rehabilitation (CR) resistance training guidelines by diagnosis

Diagnosis	AACVPR	ACSM
CABG surgery	1–3-lb hand weights on CR program entry Upper-extremity moderate to heavy resistance training 3 months after-CABG surgery	1–3-lb hand weights during convalescence and recovery Flexibility and range of motion at 24 hours after-CABG surgery TRT* at 3 months
MI	1–3-lb hand weights on CR program entry TRT* at 5 weeks if 4 weeks of endurance training have been completed	1–3-lb hand weights 2 weeks after-MI Flexibility and range of motion at 48 hours after-MI TRT* at 4–6 weeks
Pacemaker or ICD Implantation	No specific guidelines	Do not raise arm on affected side above shoulder for 2 weeks

* Traditional resistance training (TRT) = 50% of 1-repetition maximum.

to classify the exercises as "no risk," "low risk," or "high risk" for 3 diagnosis groups: MI, pacemaker or ICD implantation, and CABG surgery (Figure 1). The safety and efficacy of each exercise were analyzed for each diagnosis group to evaluate the associated risk. Safety ratings were based on the complexity of movement, the degree and depth of training for proper use, the ease of use in different training environments, and the likelihood of blunt trauma to surgical or implanted defibrillator sites.[2] Efficacy ratings express the power of an exercise to produce a positive effect for a given diagnosis, on the basis of movement variables such as pain, target muscle use, movement synergy, movement stabilization, dynamic stabilization, and antagonist stabilization for surgical or implanted defibrillator sites.[2] Numeric values ranging from 1 to 3 were assigned to the safety and efficacy scores, such that for safety, 3 = no risk, 2 = low risk, and 1 = high risk, and for efficacy, 3 = optimal benefit, 2 = some benefit, and 1 = no benefit or potential harm. Total risk for each exercise was assessed by adding the safety and efficacy scores. A total score of 6 indicated "no risk" (exercises that present no danger to the surgical or affected site), a score of 4 to 5 indicated "low risk" (exercises that, with some movement modification and incisional healing, could be safely performed), and a score of 2 to 3 indicated "high risk" (exercises with a high likelihood of injury or trauma to the surgical site and/or ICD).

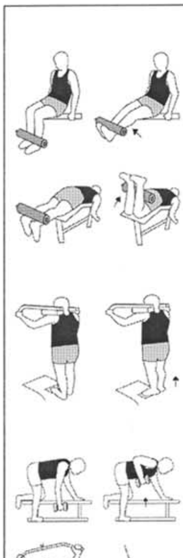
To assess the likelihood of patients exceeding safe levels of myocardial work during resistance exercise, we calculated an indirect measure of myocardial work: the rate–pressure product (RPP): heart rate (beats per minute) × systolic blood pressure (mm Hg).[3,4] In cardiac rehabilitation, heart rate and exertion level are estimated from the Rating of Perceived Exertion (RPE) Scale. The RPE Scale was first conceived by Borg[3] and ranges from 6 to 20, with verbal descriptions of exertion level patients can identify at every odd number. RPE and heart rate are linearly related to each other and to work intensity. The addition of a zero to each of the points in the scale estimates the heart rate value under various levels of work intensity. For example, 7 would become 70 and represent heart rate at rest, and 18 would become 180, which might represent a patient's maximal heart rate.[3] An RPE range of 11 to 15 is frequently used in cardiac rehabilitation settings to prescribe dynamic exercise (such as walking on a treadmill) intensity.[5] Similarly, an absolute maximum threshold systolic blood pressure of 240 mm Hg is allowed,[5] although in practice, cardiac rehabilitation staff members typically do not allow patients to reach this threshold. Taking 120 mm Hg as the regular systolic blood pressure at rest,[6] we calculated the allowable RPP range for cardiac rehabilitation dynamic exercises on the basis of these RPE and blood pressure ranges.

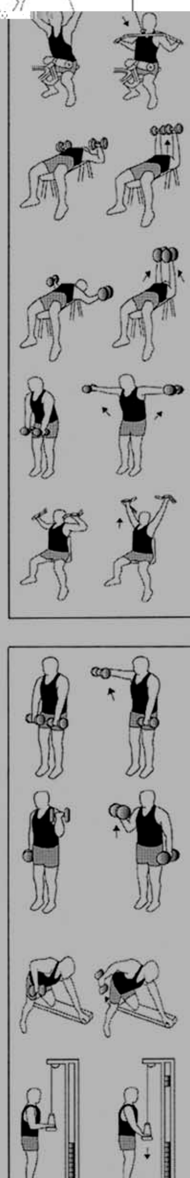
Results

The most common restriction cardiovascular rehabilitation patients reported receiving from surgeons or cardiologists from 1995 to 1997 (at Baylor Medical Center, Garland, Texas) and in 2005 (at Baylor Jack and Jane Hamilton Heart and Vascular Hospital, Dallas, Texas) was "do not lift anything >5 pounds." Other restrictions recalled by the Baylor Medical Center patients are listed in Table 2.

Pull forces for 1-, 3-, 5-, and 10-pound weights and 32 common daily activities are reported in Table 3. On the basis of these measurements, the maximum force cardiac patients should be exerting when they are in the early stages of cardiac rehabilitation is 4 force pounds (3-pound weight) according to AACVPR and ACSM guidelines or 6 force pounds (5-pound weight) according to physician recommendations. Dynamometer measurements for the 32 daily activities ranged from 4.5 to 27.5 force pounds. Only 4 required force less than or equal to that required to lift a 5-pound weight.

The results of the risk categorization of 13 standard cardiac rehabilitation weightlifting activities for cardiac rehabilitation patients, on the basis of diagnosis group (MI, pacemaker or ICD implantation, and CABG surgery), are shown in Figure 1. Five of the 13 exercises were classified as "no risk" for all 3 diagnosis groups. Patients with pacemakers or ICDs could perform an additional 3 exercises at low risk, as could those who underwent CABG surgery, although the "low risk" exercises differ between these groups. Patients with MIs could perform all 13 exercises with no increased risk. The details of safety and efficacy





Exercise	Population	Safety Score	Efficacy Score	Total Score	Time Under Restriction
Leg Extension	MI	3	3	6	0
	Pacemaker/ ICD	3	3	6	0
	CABG	3	3	6	0
Leg Curl	MI	3	3	6	0
	Pacemaker/ ICD	2	3	5	0
	CABG	1	2	3	6 weeks
Standing Calf Raise	MI	3	3	6	0
	Pacemaker/ ICD	3	3	6	0
	CABG	3	3	6	0
Dumbbell Bent Row	MI	3	3	6	0
	Pacemaker/ ICD	2	2	4	0
	CABG	2	2	4	0
Lat Pulldown	MI	3	3	6	0
	Pacemaker/ ICD	2	1	3	4 weeks
	CABG	2	1	3	6 weeks
Dumbbell Bench Press	MI	3	3	6	0
	Pacemaker/ ICD	2	1	3	4 weeks
	CABG	2	1	3	6 weeks
Dumbbell Flye	MI	3	3	6	0
	Pacemaker/ ICD	1	1	2	4 weeks
	CABG	1	1	2	6 weeks
Lateral Raise	MI	3	3	6	0
	Pacemaker/ ICD	3	2	5	0
	CABG	3	2	5	0
Shoulder Press	MI	3	3	6	0
	Pacemaker/ ICD	2	1	3	4 weeks
	CABG	2	2	4	0
Frontal Raise	MI	3	3	6	0
	Pacemaker/ ICD	2	1	3	4 weeks
	CABG	2	1	3	6 weeks
Dumbbell Curl	MI	3	3	6	0
	Pacemaker/ ICD	3	3	6	0
	CABG	3	3	6	0
Tricep Kickback	MI	3	3	6	0
	Pacemaker/ ICD	3	3	6	0
	CABG	3	3	6	0
Tricep Pushdown	MI	3	3	6	0
	Pacemaker/ ICD	3	2	5	0
	CABG	3	3	6	0

Figure 1. Safety and efficacy of resistance exercise tool. Safety score: 3 = no risk, 2 = low risk, 1 = high risk. Efficacy score: 3 = optimal benefit, 2 = some benefit, 1 = no benefit or potential harm. Total score = safety score + efficacy score: 6 = no risk (no danger to the surgical site), 4 to 5 = low risk (can be safely performed given some movement modification and incisional healing), 2 to 3 = high risk (high likelihood of injury or trauma to the surgical site and/or ICD).

Table 2
Physician recommendations after surgery involving sternotomy reported by patients in the cardiac rehabilitation program at Baylor Medical Center, Garland, Texas, from 1995 to 1997

Do not
Lift >5 lbs for 6 wks
Lift anything for 1 month
Lift anything heavy for 8 wks
Lift >2 lbs
Lift or push anything
Lift more than a gallon of milk for 4 wks
Lift anything heavier than a Dallas phone book
Pull anything for 8 wks
Mow anymore
Vacuum
Do anything but light cleaning for 7 wks
Move furniture
Play tennis until after 6 wks
Push a grocery cart
Do anything strenuous
Do yardwork for 8 wks
Do anything that would hurt you

Table 3
Forces required to perform 32 activities of daily living as measured using a Chatillon medical dynamometer (model CSD200C)

Activity*	Force lbs
Lifting 1-lb dumbbell	2
Lifting 3-lb dumbbell	4
Lifting 5-lb dumbbell	6
Lifting 10-lb dumbbell	12.5
Pushing open door to cardiac rehabilitation	15.5
Pulling open door to leave cardiac rehabilitation	22
Pushing open cardiac rehabilitation bathroom door	12.5
Pulling open door to leave cardiac rehabilitation bathroom	11
Pushing door to exit cardiac rehabilitation building	13
Pulling door to enter cardiac rehabilitation building	13.5
Opening door to enter Baylor University Medical Center	15
Pushing door to exit Baylor University Medical Center	22.5
Pulling open door at doctor's office	14.5
Pushing doctor's office door to leave	15.5
Pushing door to enter hospital room	6.5
Pushing IV pole with full drip bag across carpet	6.5
Hold elevator door from closing	14.5
Opening refrigerator	9
Opening refrigerator freezer	10.5
Pulling 1 gallon of milk from refrigerator	10.5
Lifting 1 gallon of milk	10.5
Closing microwave door	6.5
Pulling open oven door	6.5
Pulling out full dishwasher rack	5
Lifting full laundry hamper	21.5
Pushing vacuum cleaner	7.5
Pulling vacuum cleaner	8.5
Flushing industrial toilet	13.5
Lifting purse	7.5
Pulling full file drawer	10
Lifting copy machine lid	6
Lifting full coffee pot	6.5
Pushing with aid of right arm to rise off bench	27.5
Pulling chair across linoleum floor	5
Opening car door	12.5
Lifting a Dallas phone book	4.5

* All measurements involving cardiac rehabilitation, hospital, and doctor's office facilities were taken at Baylor University Medical Center and Baylor Jack and Jane Hamilton Heart and Vascular Hospital, Dallas, Texas.

scores for each exercise, on the basis of diagnosis group, are included in Figure 1.

On the basis of the RPE and systolic blood pressure ranges recommended for dynamic exercise in cardiac rehabilitation, allowable RPPs ranged from 13,200 (110 beats/min heart rate × 120 mm Hg systolic blood pressure) to 36,000 (150 beats/min heart rate × 240 mm Hg systolic blood pressure).

Discussion

Similar to the AACVPR and ACSM guidelines, we found that the activity advice physicians gave patients after surgery involving sternotomy was vague and/or overly restrictive, not taking into account which muscle groups patients could safely use without risking damage to the surgical site. Furthermore, following the common physician recommendation of not lifting >5 pounds would preclude patients from all but 4 of the 32 common daily activities we investigated. Following the AACVPR or ACSM guidelines (lifting only 1 to 3 pounds) is even more restrictive. Particularly ironic is that following these guidelines in daily activities would preclude patients from pushing or pulling open a standard doctor's office door, and, specific to our study, the door of the cardiac rehabilitation building (Table 3).

The current resistance training guidelines and physician advice used in cardiac rehabilitation have good components, but there are 2 problems. First, patients are frequently told "no weightlifting" as the simplest way to communicate that they should avoid such exercises as bench presses and pectoral flys, which physicians legitimately fear after CABG surgery or pacemaker or ICD implantation because they carry the possibility of damage to the sternum or lead displacement. In fact, weightlifting or resistance training encompasses a wide variety of exercises using dumbbells, free weights, and machines that target specific muscle groups. As shown when we categorized the risk associated with13 common resistance training exercises for the 3 cardiac rehabilitation diagnosis groups (MI, pacemaker or ICD implantation, and CABG surgery), there were no patients who could not safely do at least some resistance exercises (Figure 1). Therefore, rather than being told to do no weightlifting exercises or to use 1- to 3-pound weights for a certain time, patients should be advised to do safe weightlifting exercises, as determined from a tool such as we suggest in Figure 1.

The second problem with current guidelines is that no differences are made in prescribing weights on the basis of patients' age, gender, or fitness levels. Given the very small weights recommended, the error is more likely to be in the direction of undertraining younger or fitter patients than overexerting frailer patients. For example, if a patient were to do a 5-pound dumbbell curl when his or her maximum dumbbell curl weight is 50 pounds, the percentage of his or her 1-repetition maximum would be only 10%, eliminating almost any training effect.[7] By changing the guidelines to specify safe exercises rather than specific weights, this problem could be eliminated because the exercises could be performed at the level and intensity appropriate to a patient's health and ability.

The traditional perception that resistance exercise is harmful to cardiac patients is not supported by scientific data.[5] After MI, pacemaker or ICD implantation, and CABG surgery, it is important to remain active to avoid physiologic atrophy and decline. Resistance exercise training improves skeletal muscle strength and endurance and is important for the safe return to activities of daily living.[5] Patients can benefit from the use of the principle of exercise specificity: the choice of exercise modes and muscle groups used should be consistent with a patient's diagnosis and vocational and leisure time requirements.[5] Very often, patients' goals after cardiac procedures involve the use of muscular strength and endurance (e.g., gardening, mowing, lifting grandchildren, vacuuming).

After CABG surgery, there is significant soft tissue and bone damage to the chest wall and the anterior and superior regions of the arms and shoulders.[3] We are not suggesting that this damage should be ignored or that patients should be encouraged to participate in exercises that would exacerbate the damage, but long-term immobilization is not necessarily in their best interests either. Likewise, upper-body immobilization after pacemaker or ICD implantation procedures leads to muscular atrophy and weakness (J. Pressley, personal communication, March 24, 2005). If these areas (joints, muscles, and other supporting tissues) are not taken through their range of motion, adhesions develop, and muscles weaken. To exacerbate this problem, patients typically favor surgical sites, causing difficulty in regaining previous strength and full range of motion. Participation in exercise increases blood flow to the damaged area and accelerates tissue repair. It appears that the longer the delay in upper-body range of motion exercise, the more difficult it is to reach full recovery.[3]

Essentially 2 fears govern the current restrictions on resistance training in cardiac rehabilitation. The first is the fear that resistance training will increase the risk for injury to the surgical site. This varies by diagnosis, for example, sternal dehiscence in patients who undergo CABG and dislodging the pacemaker or ICD in patients with implants. The problem can be simply addressed by using a tool such as we present in Figure 1. Patients' exercise prescriptions should be based on assigning them exercises that do not risk injury to their specific surgical sites on the basis of their degrees of healing, in addition to determining the exercise intensity on the basis of standard cardiac rehabilitation exercise prescription variables, such as the presence of uncontrolled arrhythmias and small ejection fractions.[8]

The second fear restricting resistance exercise in cardiac rehabilitation is of the perceived potential restrictive exercise has to place more strain on the heart than dynamic exercise. Historically, the notion has been that myocardial work (measured as RPP) is much greater during resistance exercise because of the invariable increases in blood pressure that occur with the Valsalva maneuver, which patients may use if they do not receive proper instruction in performing the exercises. Because the concern here is the increase in blood pressure and heart rate that occurs during exercise, a better solution than the current tight restrictions on allowable weights and the timing of resistance training would be to provide guidelines addressing safe ranges of heart rate and blood pressure. These have already been established in cardiac rehabilitation for dynamic exercise.[5] Because the same cardiac rehabilitation patients would be performing the resistance training, it seems logical that the same ranges would apply to resistance training. Under the current dynamic exercise recommendations, this allows a RPP of up to 36,000. One study that evaluated a strength training program for cardiac rehabilitation patients—including horizontal squats, shoulder presses, leg extensions, lat pull-downs, and bicep curls—measured RPP values for high-risk cardiovascular patients doing the 1-repetition maximum horizontal squat.[9] The investigators reported RPPs ranging from 12,320 to 22,780 for this exercise,[9] which is significantly less than the 36,000 allowed during dynamic exercise.

A similar approach of patient-specific exercise prescription should be applied to resistance exercise. Patients undergoing cardiac rehabilitation should be told to be careful and to avoid certain activities that carry a high risk for them on the basis of their specific diagnoses. From there, patients and cardiac rehabilitation specialists should work together on the activities the patients can perform safely, monitoring symptoms rather than the weight used. For too long, we have been impeding patients' recovery through overly restrictive safety precautions on resistance exercises. It is time to change cardiac rehabilitation guidelines and recommendations to take into account the physical and physiologic limitations of patients for resistance exercises, as we do for dynamic exercises. This will allow care providers and patients to tailor exercise programs to promote higher fitness levels, increased range of motion, increased strength, greater bone density, and increased patient satisfaction and participation.

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